Geological Site Characterization Of The Nearly Depleted K12-B Gas Field, Offshore The Netherlands

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TNO | Knowledge for business

Outline

- Objective
- K12B field - Overview
- Reservoir characterization
  - Sedimentary facies
  - Faults
  - Diagenesis
  - Geocellular model
- Seal characterization
  - Identification & correlation of salt minerals
- Conclusions

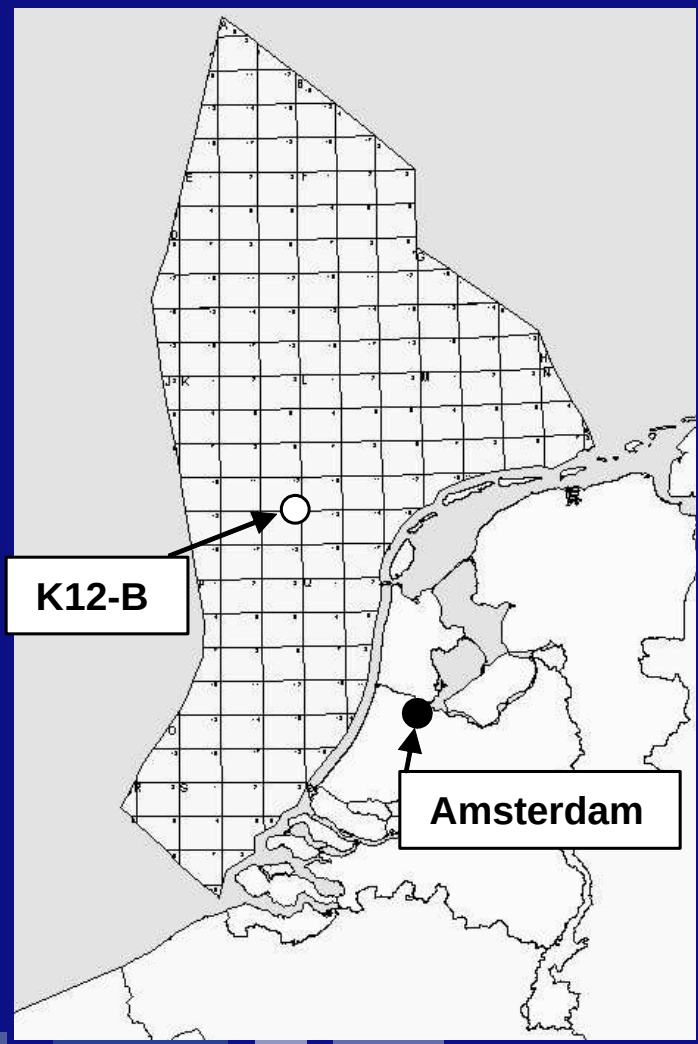
Objectives

- To re-evaluate the sealing capacity and the injectivity of the reservoir in view of the pressure drop of 400 bar to 40 bar due to the gas production over the last two decades.

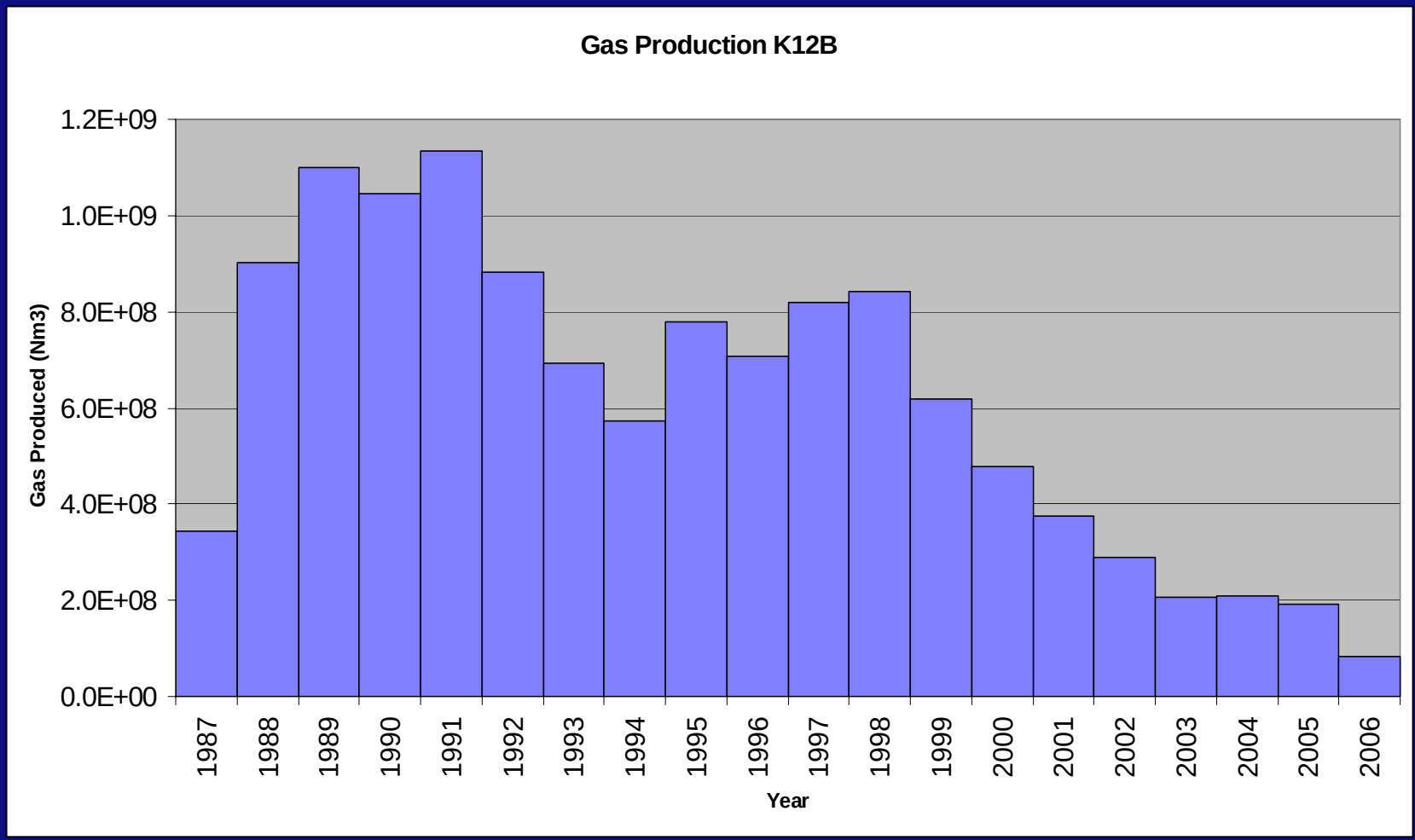
- To build an accurate geological model of the K12B reservoir and seal that can serve as a basis for future studies in:
  - CO_2 flow behavior in the reservoir;
  - Enhanced gas (methane) recovery;
  - Cap rock behavior;
  - Well – Reservoir interface

K12-B Field - summary

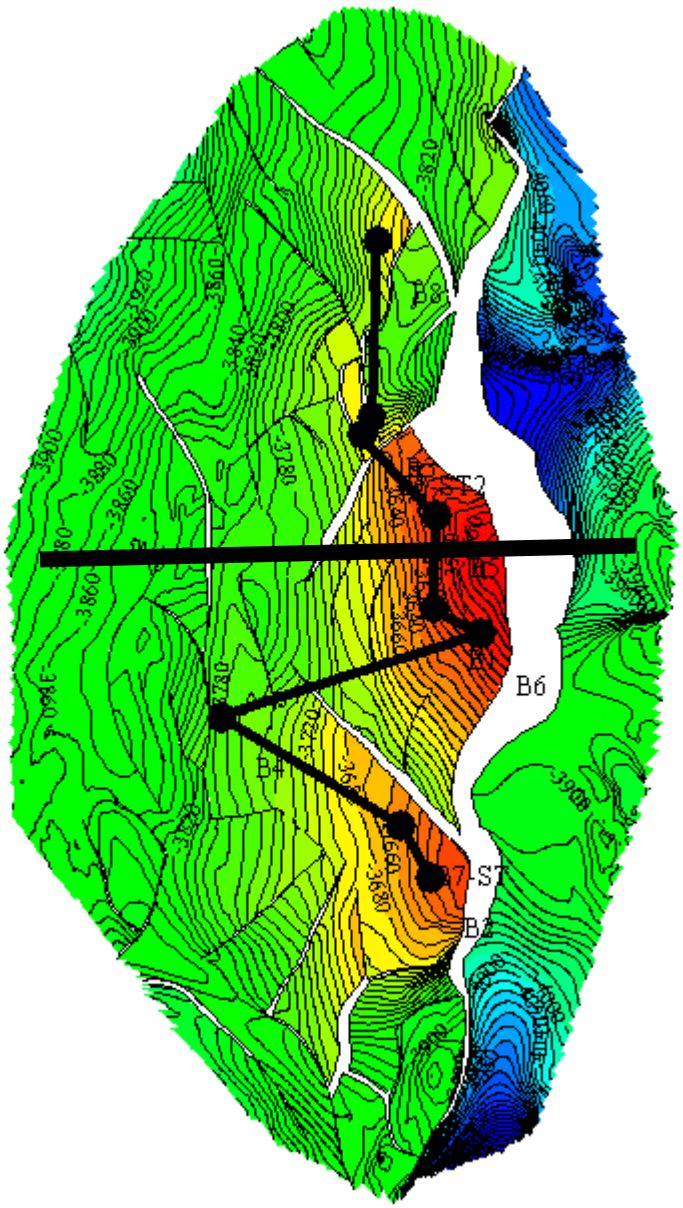
- Offshore The Netherlands, Rotliegend fairway
- Discovered in 1981, on stream since 1987
- Operated by Gaz de France
- GIIP: 13.7 BCM
- Produced so far: 12 BCM (Jan 06)
- Gas composition: 13% CO_2
- Scope for recovery: CO_2 injection

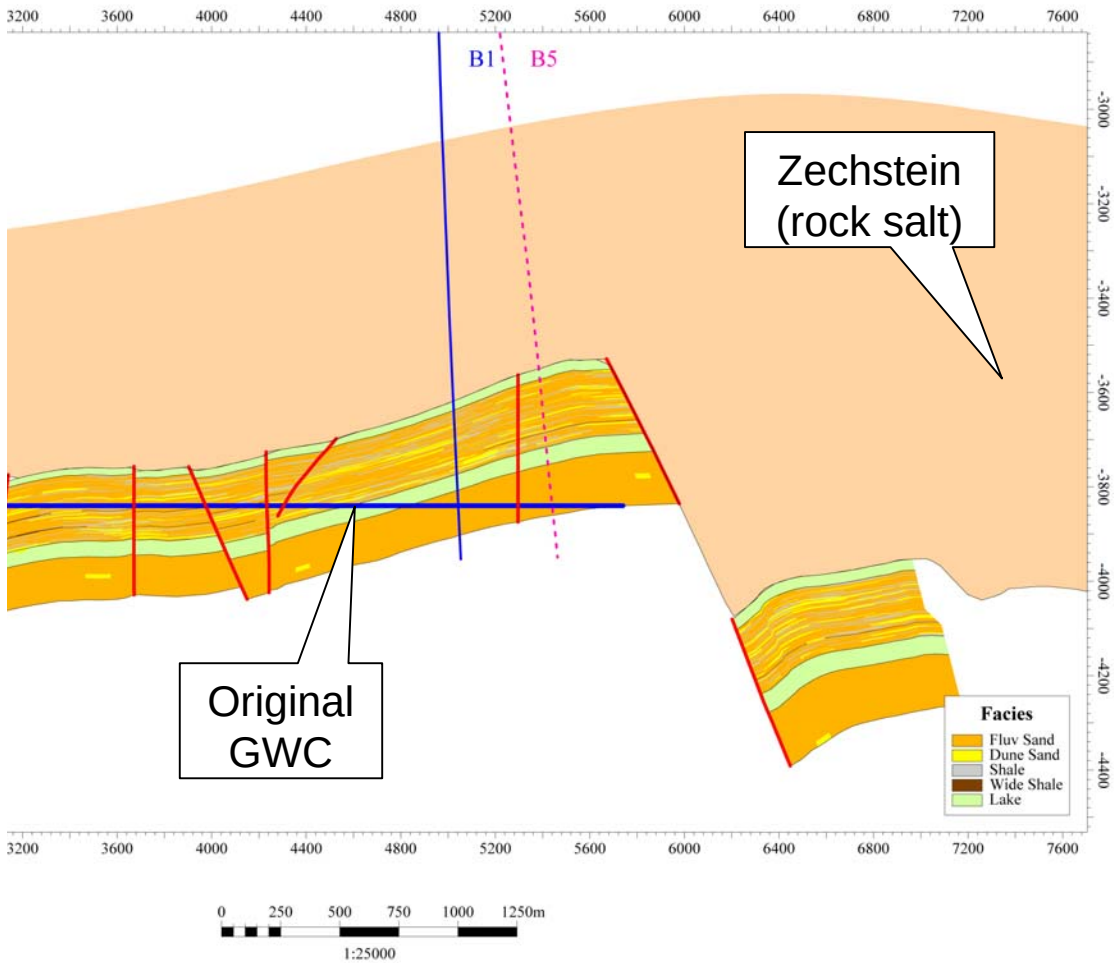


K12B Field – Gas Production

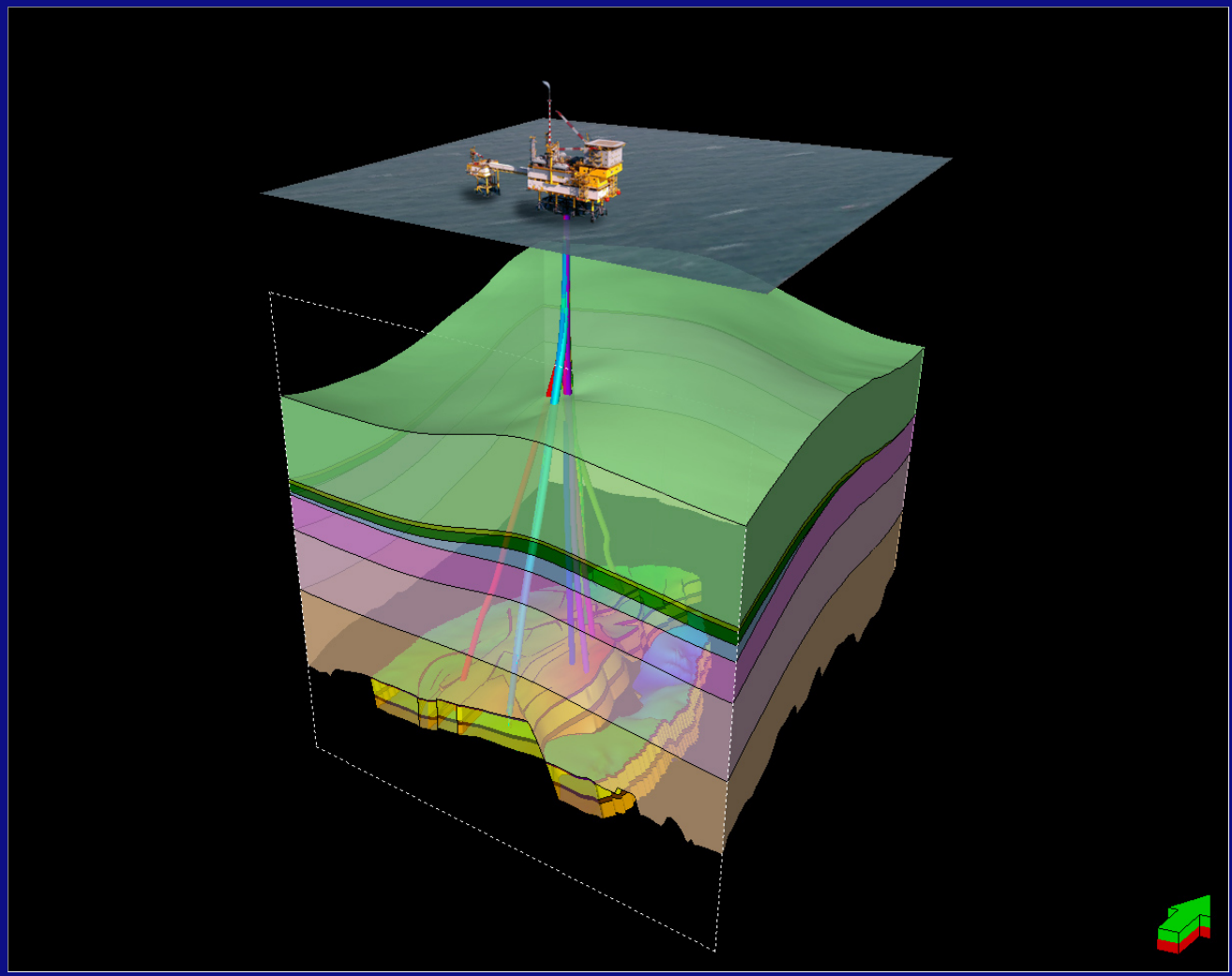


K12B Field – Map and Cross-section

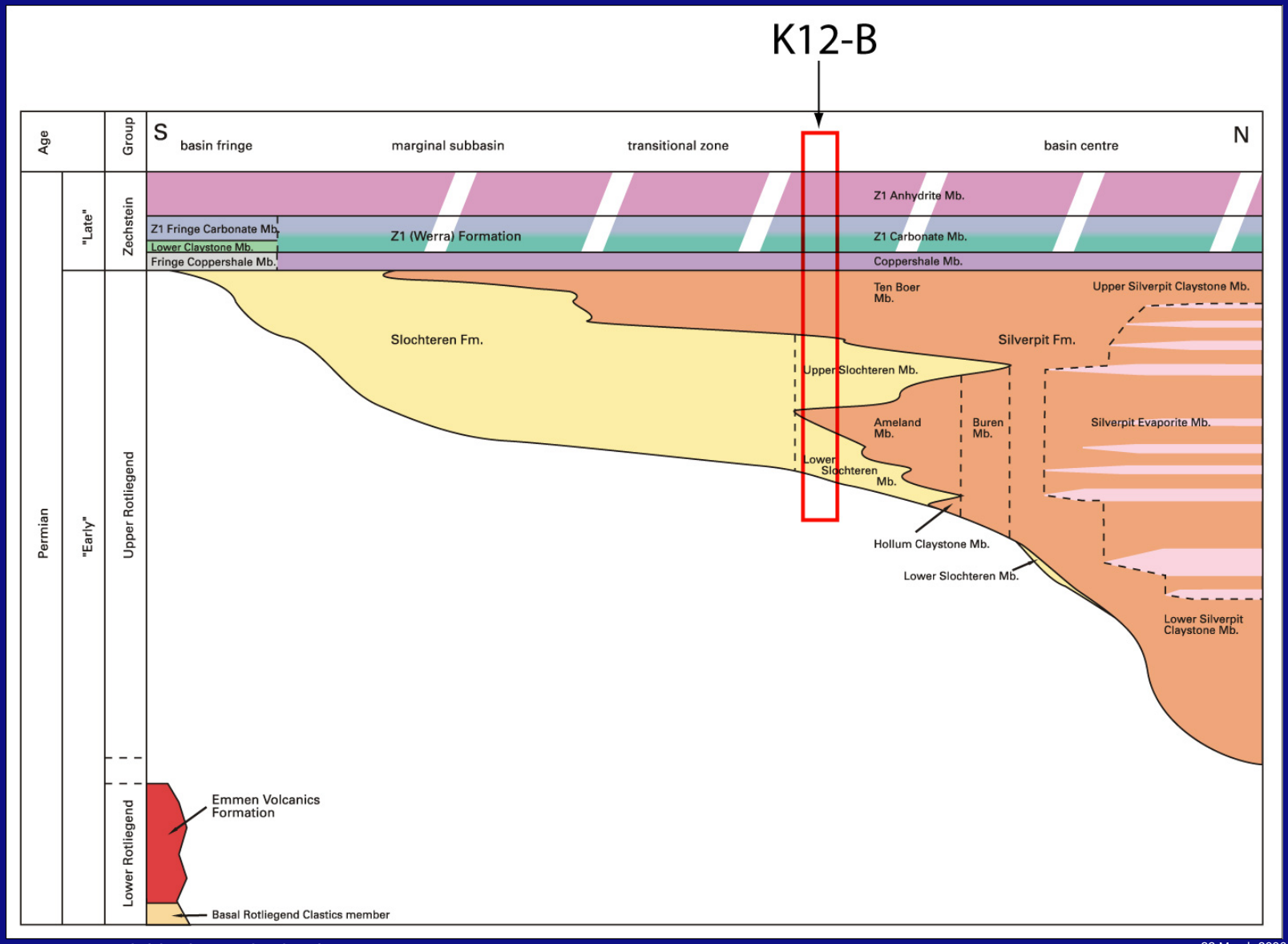




K12B Field - Geological model of reservoir and overburden

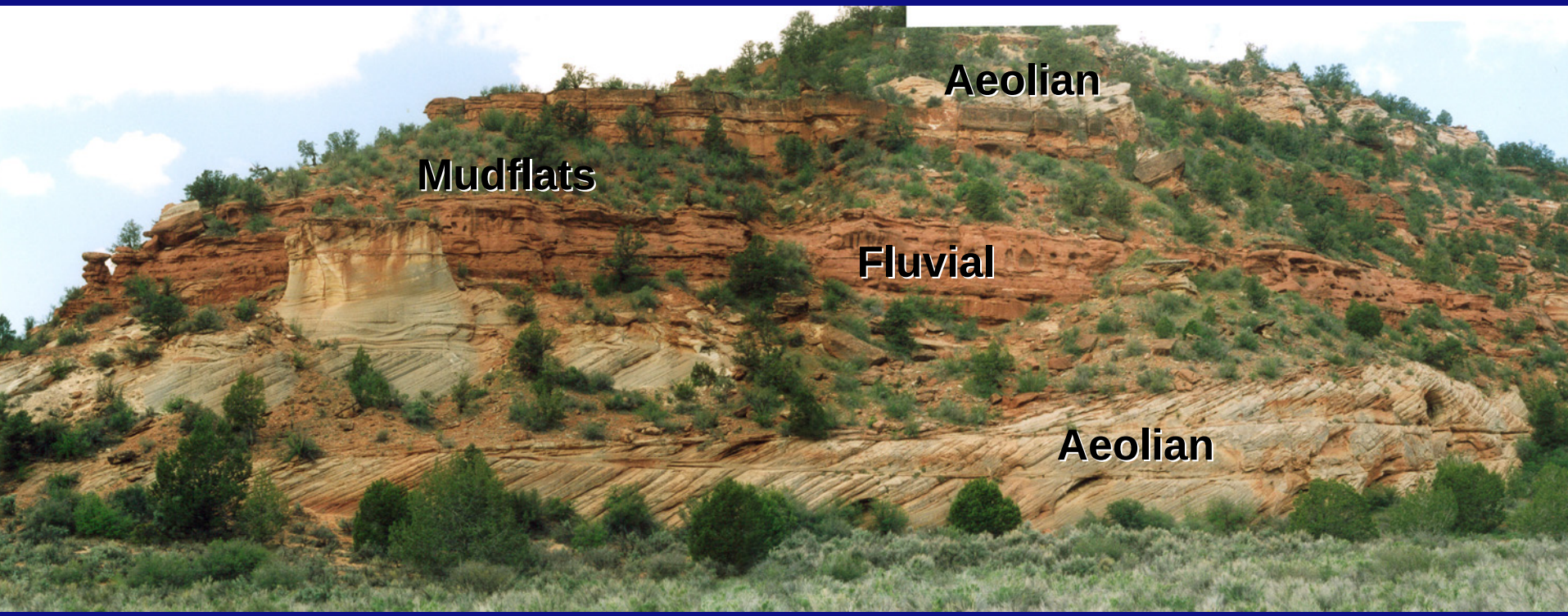


Stratigraphy

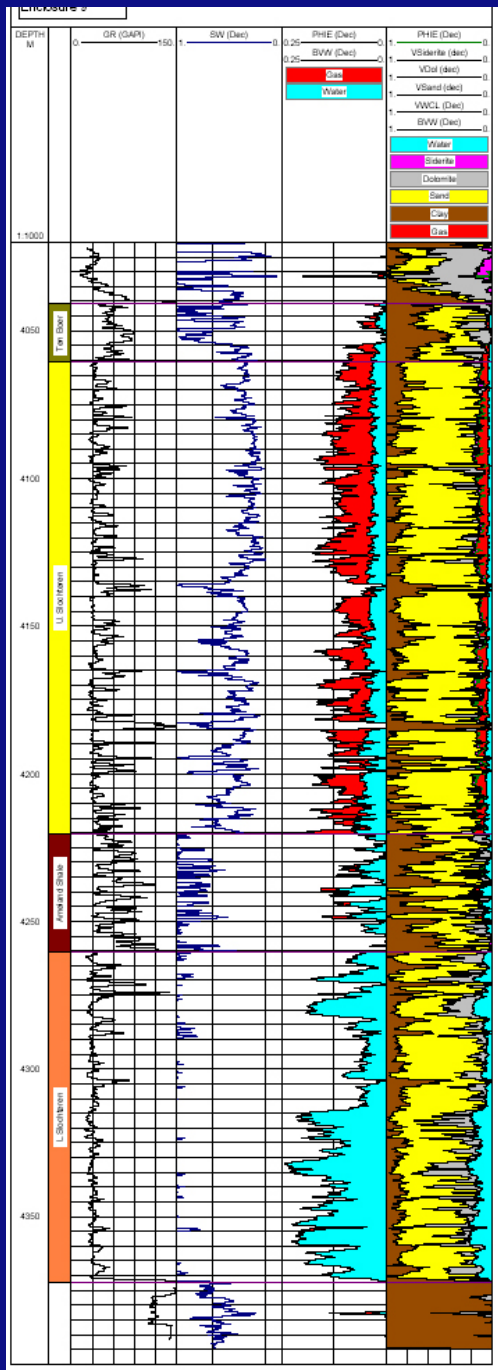


Slochteren Sst – Core Material

Navajo Sst, Kanab – A mixed aeolian / fluvial outcrop analogue for the K12B Field



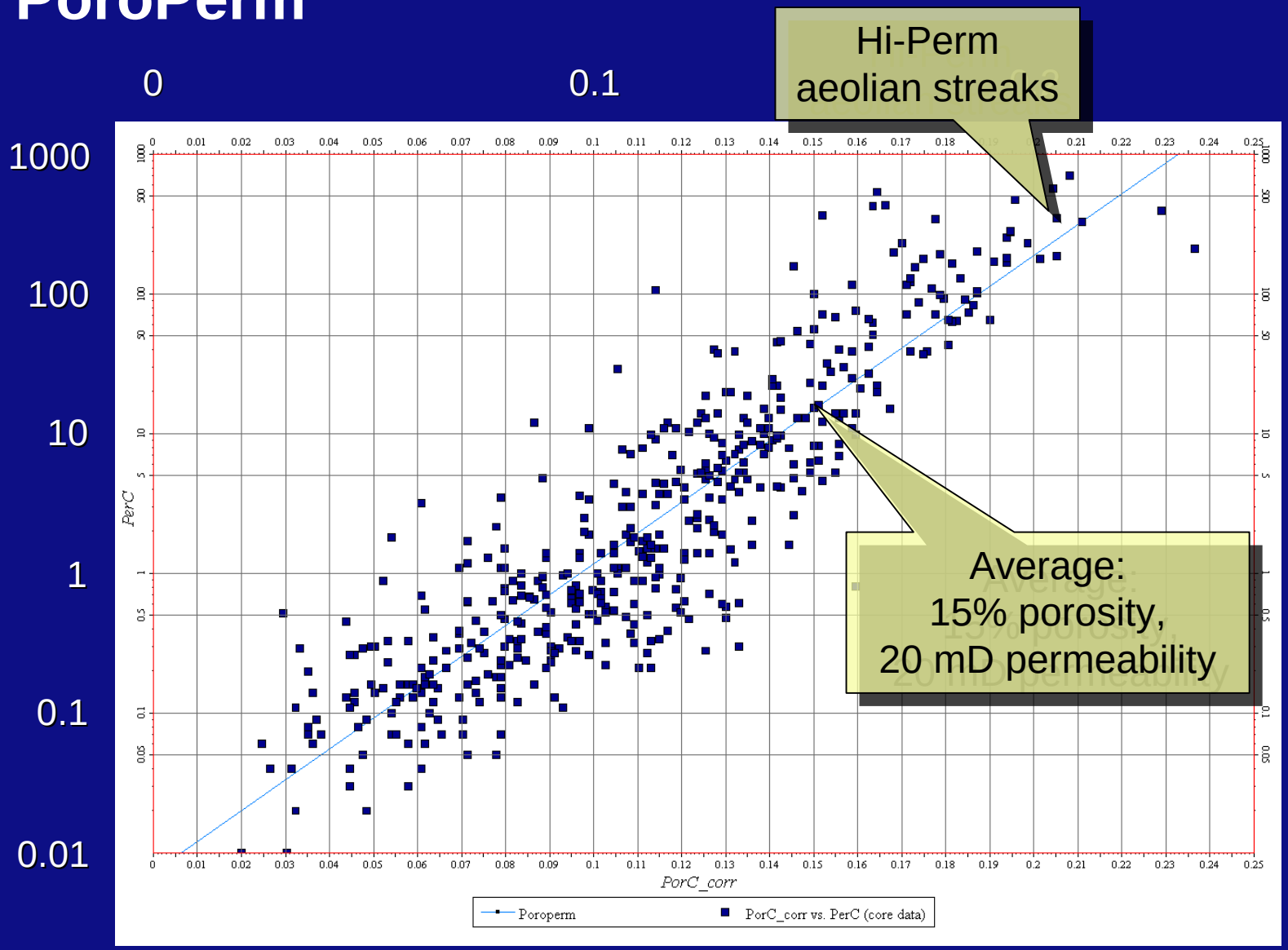
Well log summary K12-B7 (Initial water saturation)



Facies characterization

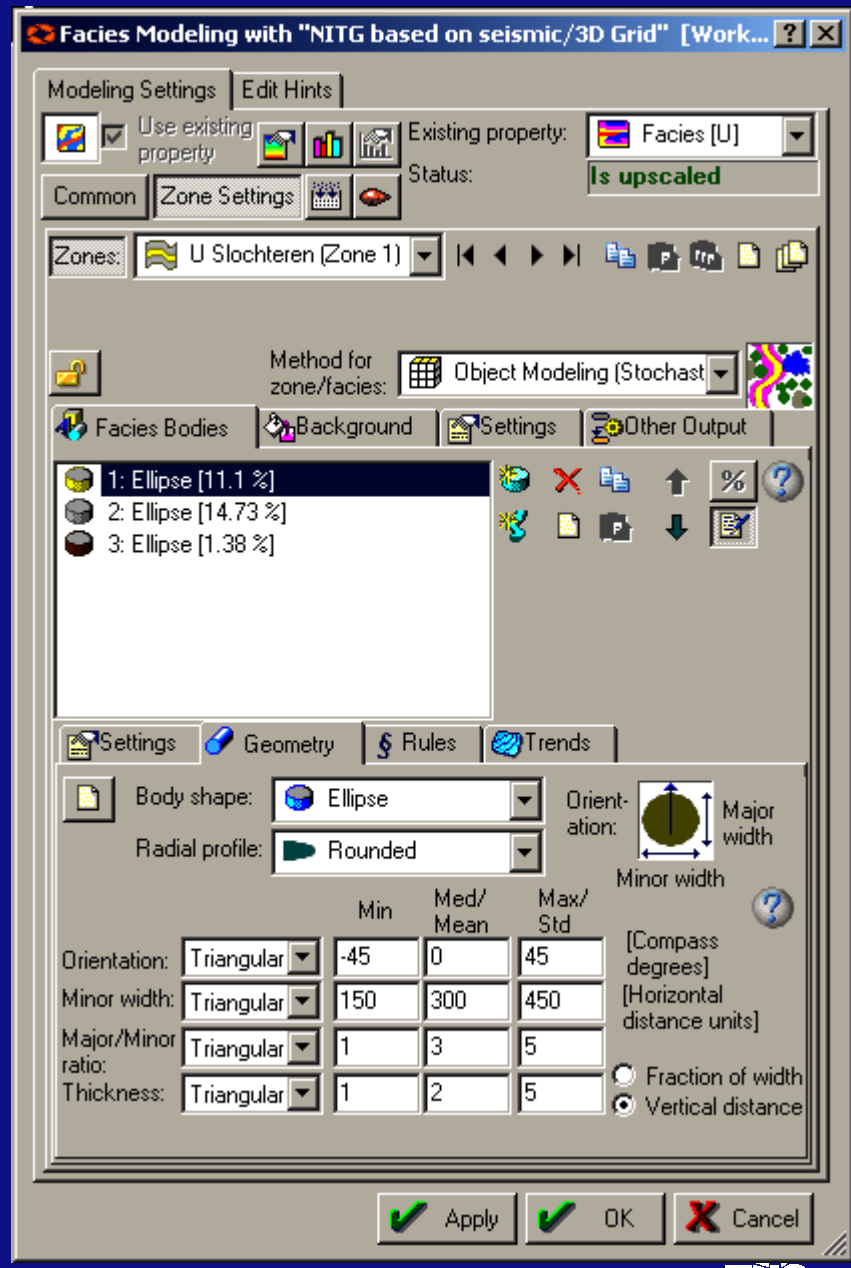
- Fluvial Sandstone (75 %)
  - Bulk of the reservoir
  - 5-30 mD
- Aeolian Sandstone (11%)
  - 2-5 m thick, 100’s m wide, elongated
  - 300-500 mD
  - Hi-perm streaks
  - Produces 90% of the gas in the wells
- Shales (16%)
  - Thin (0.1 – 1 m)
  - Varying extent (100’s m’s to km’s)

PoroPerm

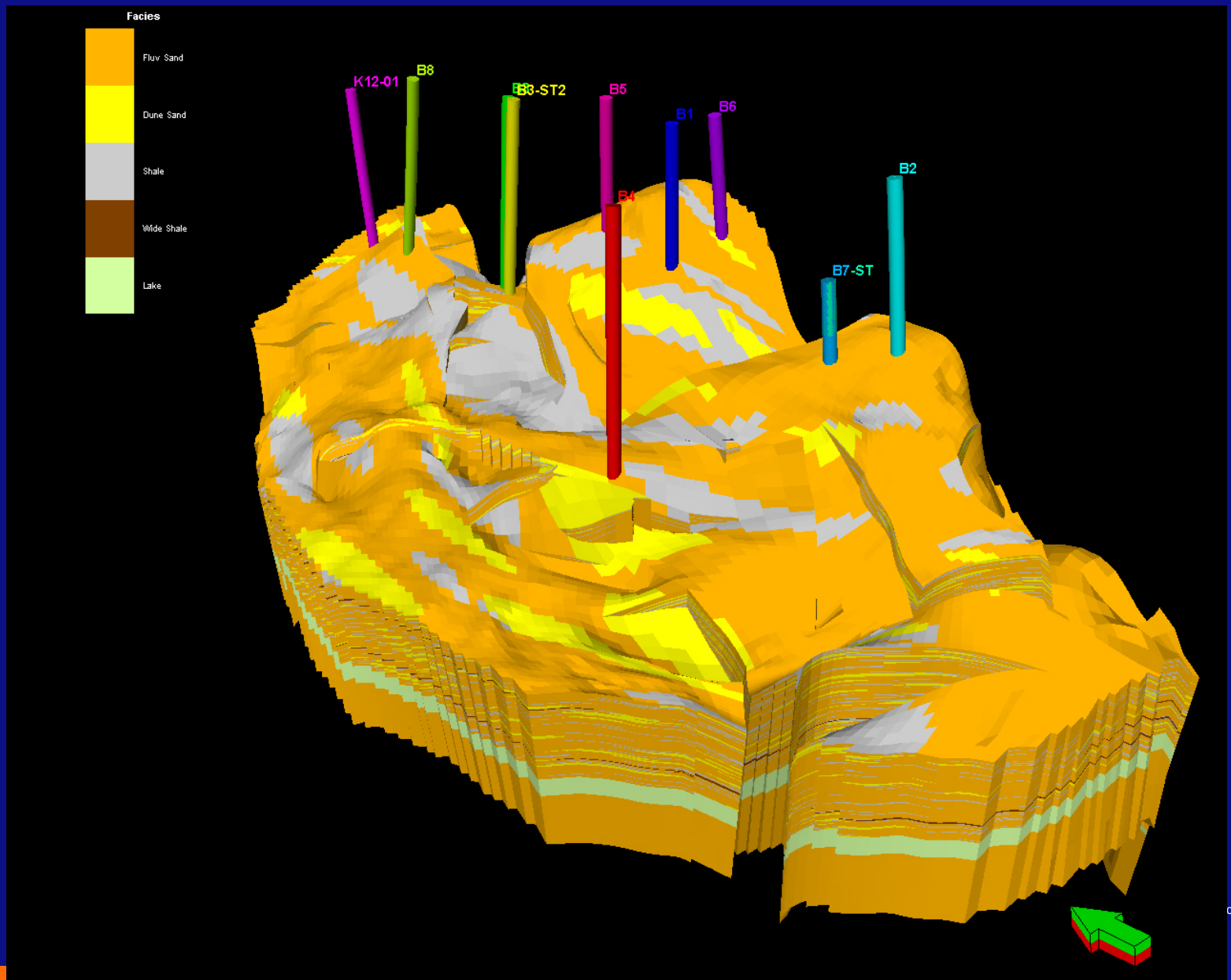

Hi-Perm
aeolian streaks
Average:
15% porosity,
20 mD permeability
PerC
PorC_corr
Poroperm
PorC_corr vs. PerC (core data)

Facies modelling

- Background facies is fluvial (wadi) sandstone
- Aeolian and shale streaks are modeled as ellipses



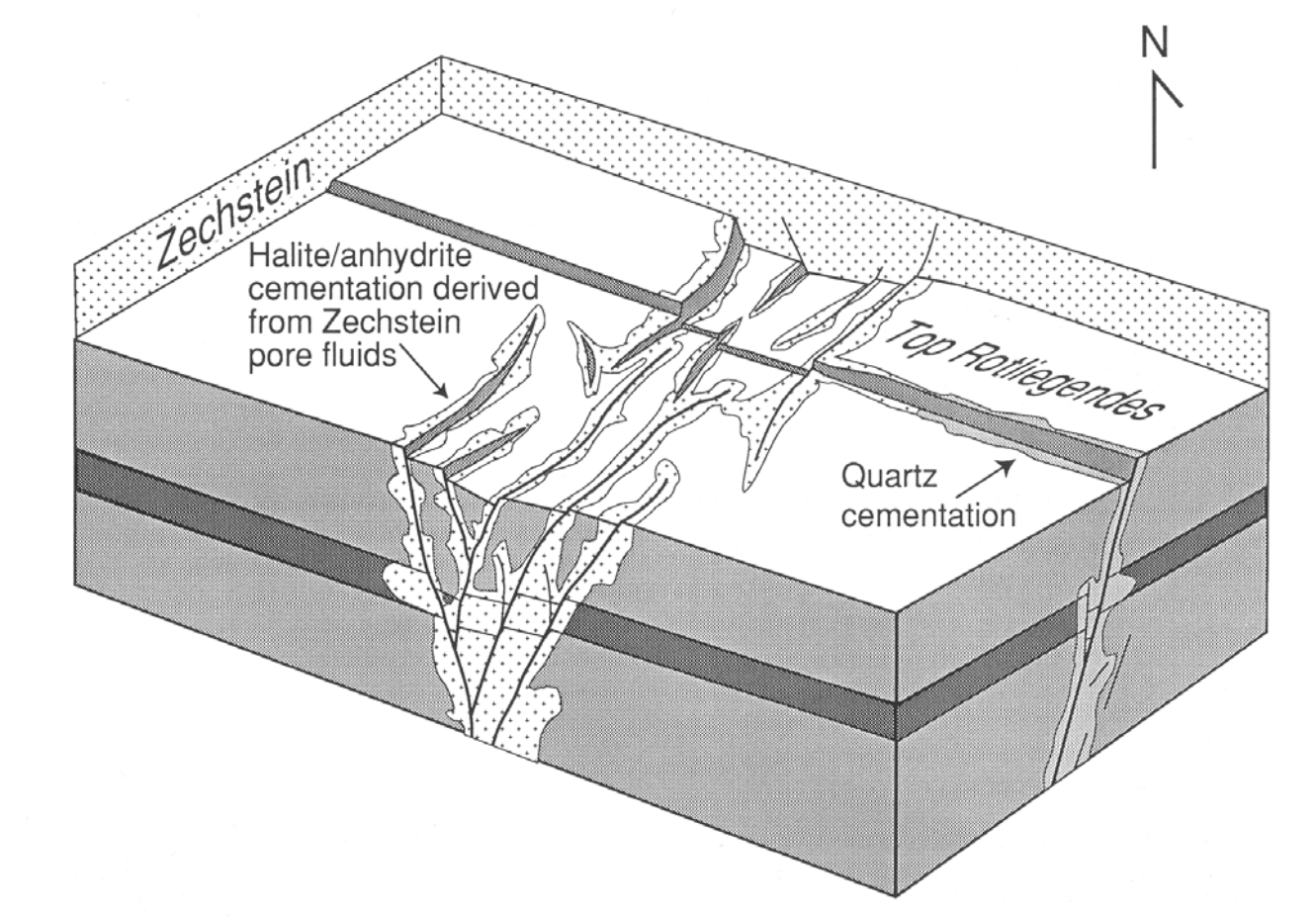
Facies realization



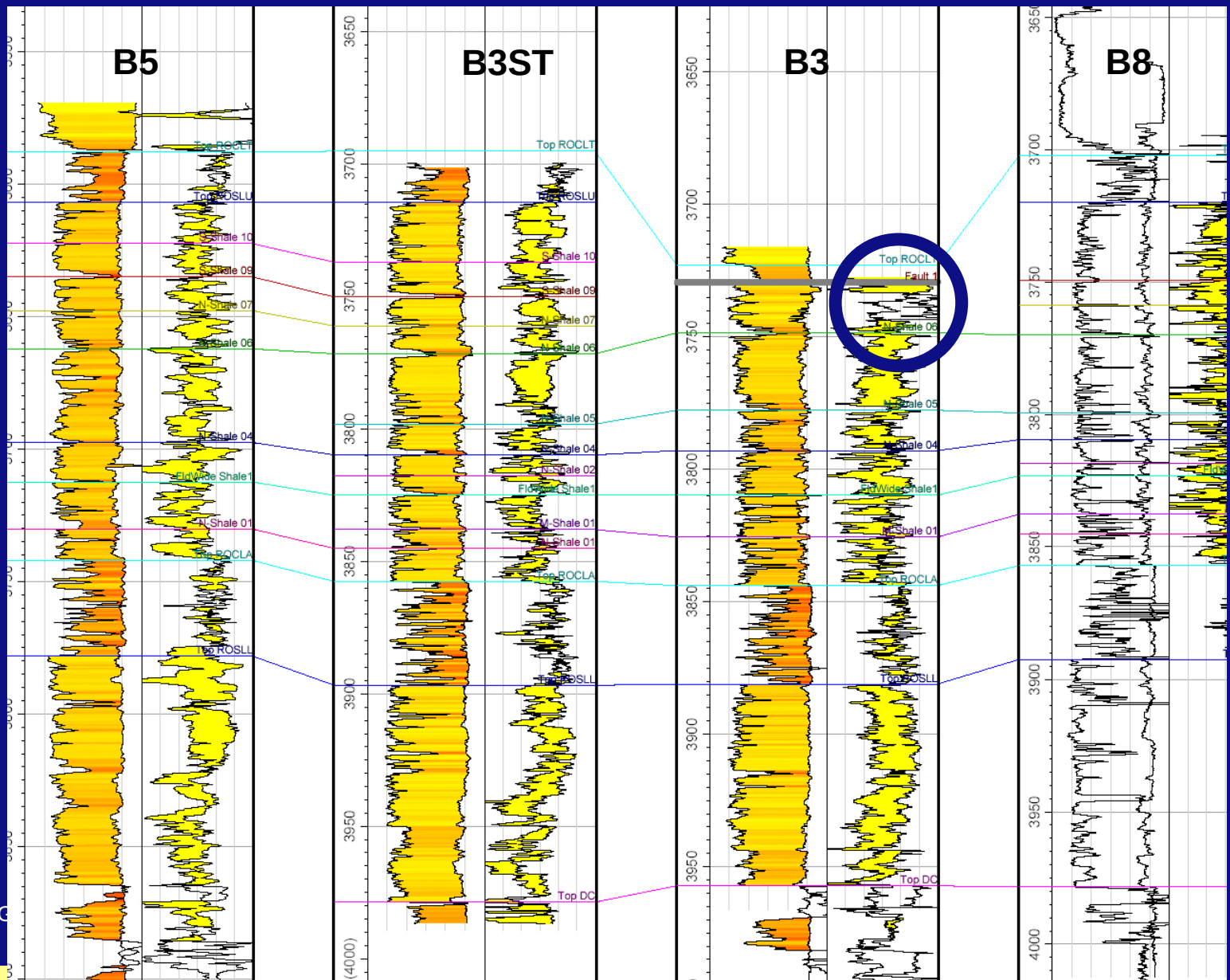
Faulting

- All faults are normal faults with modest throws (10-100 m)
- None of the faults reaches the top of the seal
- Most faults are completely cemented (sealing), as testified by:
  - Good agreement volumetric GIIP and dynamic GIIP (P/z) of individual fault blocks;
  - Virgin reservoir pressures in undrained compartments;
  - Direct evidence.

Quartz- and Halite/Anhydrite cemented faults



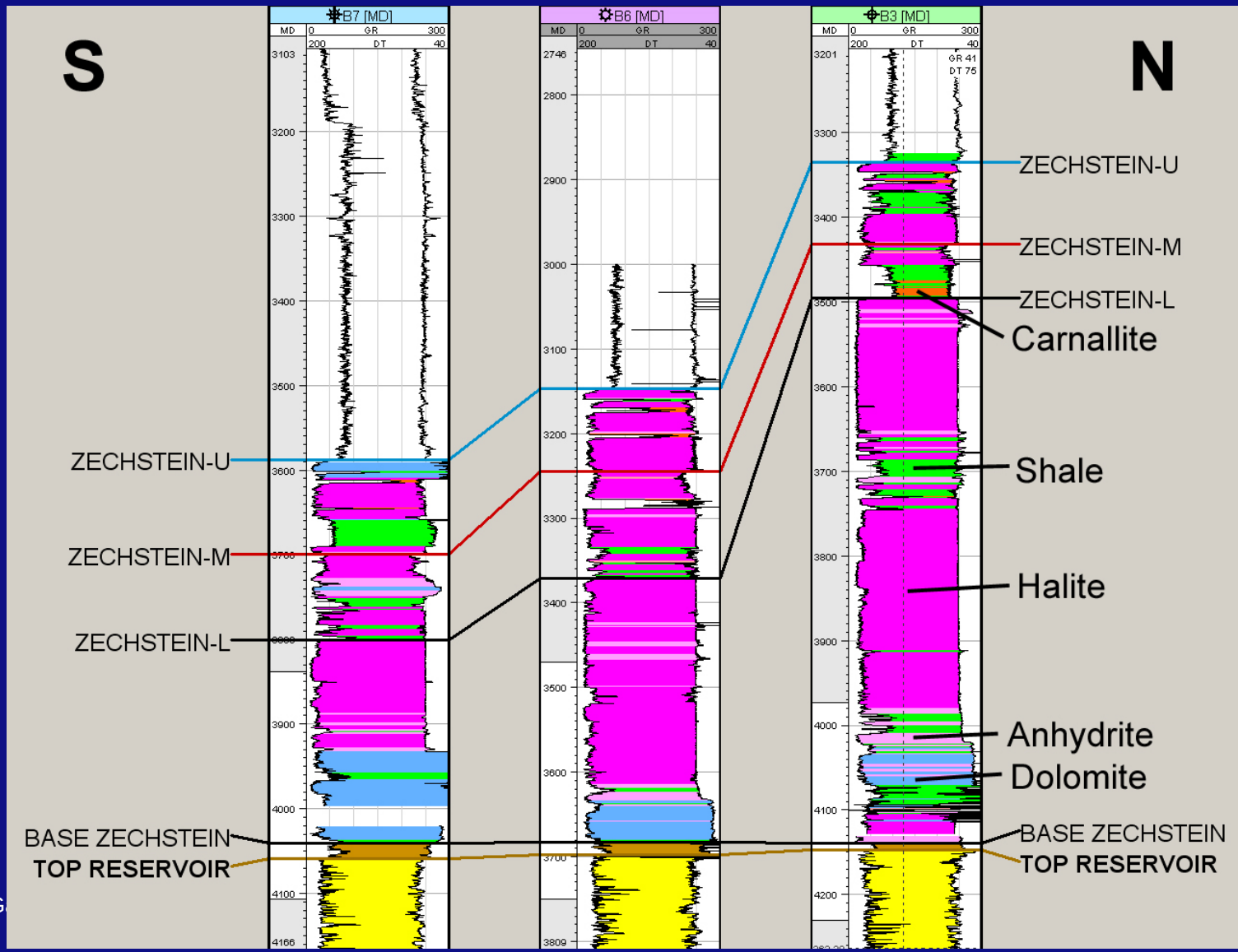
Further evidence for fault cementation: B3 well



Seal Characterization

- Zechstein contains up to 4 evaporite cycles
- Identification and correlation of evaporite minerals
- Special attention to squeezing salts, e.g. Carnallite and Bishoffite

Seal Characterization



Summary

- The K12-B Upper Slochteren reservoir is highly heterogeneous due to sedimentary, diagenetic, and tectonic processes.
- Diagenesis is considered to be the main controlling factor for fluid flow.
  - Reduced vertical permeability;
  - Cemented faults;
  - Reduced reservoir properties in the water leg
- None of the reservoir faults reaches the top of the seal
- ➔The K12-B Field is suitable for storage of CO_2
- A reservoir-geological Petrel model was built in accordance with these findings.